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Design Thinking-Based Lesson Plans in Statistics and Probability

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Design Thinking, Lesson Plans, Needs Assessment Survey, Performance Task, Validity

ABSTRACT

The study focused on the development of Design Thinking-based Lesson Plans (DTLPs) in Statistics and Probability based on the learning competencies that need performance tasks as perceived by the Grade 7 Mathematics teachers of the Diocese of Laoag Catholic Educational System (DLCES). The study used descriptive research design incorporating the three (3) phases of Research and Development (R & D) methodology, namely, the planning phase, development phase, and validation phase. There are two (2) data gathering instruments used in this study, namely, 1) Needs Assessment Survey on Performance Tasks and 2) Validation Tool for the Design of Thinking-based Lesson Plans (DTLPs). The needs assessment survey was based on the learning competencies prescribed by the K to 12 curriculum. Meanwhile, the validation tool was aligned with the general characteristics of a performance task established by McTighe *et al.* (2020) and patterned with the Assessment Validation Checklist by the Center for Collaborative Education (2012), and Hess (2009). Frequency count, percentage distributions, and rank were used to determine the learning competencies that need performance tasks. Meanwhile, means were used to describe the validity of the developed DTLPs along with content, instructional, and assessment characteristics. The developed DTLPs were validated by the panel of experts as highly valid in all the three (3) identified characteristics. Thus, the developed DTLPs can be used in classroom instruction to foster creativity, problem-solving and critical thinking skills among learners in teaching Grade 7 Statistics and Probability.

INTRODUCTION

The birth of the digital age, increased mobility, and widespread of information urge people to adapt with the abrupt changes brought by the demands of the 21st century because the traditional approaches often seem ineffective, so new tools and approaches need to be established (Luka, 2014). This may imply that teachers' pedagogies must be improved and made more relevant, especially when facing complex and varied educational challenges. Education experts pointed out that there is a call to design new learning environments and opportunities that correspond to the call of times, like capacitating students' skills and tools in order to bring out new and innovative ideas and solutions to complex challenges (Steinback, 2010).

As people begin to indulge on the challenges of the 21st century, the world is already in the era of the fifth Industrial Revolution (IR 5.0) where humanism, civility, inclusivity, creativity, and purpose thrive alongside profit and digitally enabled progress (Thurston & Hayes, 2021). But, as humans move toward human-machine collaboration in IR 5.0, it is still crucial to continuously improve those specifically human skills that machines have not yet mastered, such as creativity, complex decision-making, team leadership, and empathy.

This transition certainly made a great impact to various sectors, especially, in the field of education. It is a great challenge to educators to prepare sufficient human resources who are capable to adapt and compete on a global scale. Thus, teachers in this generation are now required to have the expertise, abilities to adapt to new technologies, and teaching strategies that could benefit in fostering student's creativity, problem solving skill, and the needed skills in the 21st century.

In connection to the different changes that had happened, the Philippine Education System finds its way to improve the basic education curriculum and evolve to K to 12 Curriculum in order to meet the demands of the 21st century. However, the country remains at the bottom, and has poor standing in different assessments conducted internationally, like the recent result of the Programme for International Students Assessment (PISA) in 2018 which revealed that the Philippines scored 353 in Mathematics which is below the average score of 489 points among participating Organization for Economic Cooperation and Development (OECD) countries. This international assessment rating coincides with the results of the country's recently concluded National Achievement Test (NAT). In 2018, the national mean percentage score among Grade 10 students was 44.59% which is below 75% Mean Percentage Score (MPS). With these results, the Department of Education (DepEd) recognizes the urgency of addressing issues and learning gaps to improve the academic standing of the Philippines internationally and provide a quality education among Filipino learners.

Alongside with the dismal performance of Filipino learners in international and local assessments, Alonsabe (2018)

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stated that some of the factors that could contribute to it are the quality of learning resources, evaluative devices, and teaching materials. Evidently, inefficient and outdated learning materials, activities and tasks significantly affect students' learning condition. In reality, the Department of Education (DepEd) faces many challenges because some of the textbooks and activities in the modules given to learners are with enormous errors, poor and obsolete, and do not conform to learning competencies and skills (Ambag, 2018).

On the other hand, it is necessary to provide learners with relevant learning activities or tasks in order to develop the skills needed in the 21st century, and to equate or even surpass the academic standing of other countries in international assessments. Albay and Eisma (2021) stressed that as part of the school's mandated duty to support a 21st century classroom, learners must be provided with activities and assessments that prepare their skills.

In relation, DepEd Order No. 8, series of 2015, also known as Policy Guidelines on Classroom Assessment for the K to 12 Curriculum, states that performance task is one of the components in assessing learners' standing in which 40% from the grade of learners in Mathematics is being computed through their performance tasks. Also, during the outbreak of COVID-19 pandemic across the country in 2020, the Department of Education implemented DepEd Order no. 31, series of 2020, also known as the Interim Guidelines for Assessment and Grading in Light of the Basic Education Continuity Plan for SY 2020-2021. In this order, the computation of the grade of learners in Mathematics through their performance tasks were raised to 50%. Thus, performance tasks play a vital role for students to acquire and master desired skills in Mathematics. Additionally, it prompts students to use higher-order thinking skills such as analysis, synthesis, and evaluation (Lund & Kirk, n.d.). They also added that the more opportunities students are given to practice these skills, the more proficient they become at using them.

Along with the performance tasks given to learners, learning strategies must be incorporated to help learners better understand and perform an indicated task. According to Dolak *et al.* (2013), design thinking in the realm of education provides avenue to escalate students' performance in terms of creativity, endurance, engagement, and innovation. Collins (2019) emphasized that in education, a design thinking curriculum immerses students and teachers in real-world problem solving. So, students are given learning opportunity to develop their problem solving and critical thinking skills through the Design Thinking Process, as they are immersed with problems on real-world situation.

While many people see design thinking as a linear process. Kelly (2019) stressed that it is a cyclical series of experiments with a goal to find best possible answers and solutions to a certain problem. On the other hand, Kelly (2019) does not deny the fact that design Thinking has an image problem, in the sense that when a person tries to use the processes of the design, they sometimes have misconceptions on the processes especially when they lack training on it. Considerably, it is important to give ample time to learn the human-centric components of the methodology and how to apply it in teaching mathematics in order to properly and effectively use the salient features of the design.

It is from this context that the researcher was motivated to incorporate the processes involved in design thinking and performance task assessment as necessary components in making Design Thinking-based Lesson Plans (DTLPs) to address different learning gaps in Mathematics education. Likewise, these DTLPs will help learners to develop their problem-solving and critical thinking skills and, thereby, support the delivery of lessons in the K to 12 curricula, particularly in Mathematics education.

LITERATURE REVIEW

The review of literature is organized in four discussions, namely, a) Philippines K to 12 Mathematics Curriculum, b) Performance Task Assessment in the K to 12 Curriculum, c) Design Thinking Process, and d) Design Thinking-based Performance Tasks.

Philippines K to 12 Mathematics Curriculum

With the 2013 enactment of Republic Act (RA) No. 10533, popularly known as the Enhanced Basic Education Act, the Philippines implemented its K–12 Program as part of the government's ongoing commitment to high-quality education.

The Philippine Mathematics Curriculum is envisioned to develop students' critical thinking and problem-solving skills. Critical thinking is the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from or generated by analysis, expertise, reflection, reasoning, or communication as a guide to belief and action (Scriven & Paul, 1987; the K to 12 Curriculum Guide in Mathematics, 2016). In a similar manner, Polya (1962) defined problem solving as finding a way around a difficulty, around an impediment, and finding a solution to a problem that is unclear. Additionally, it is stated in the K to 12 Curriculum Guide in Mathematics (2016) that these goals must be met with a well-structured and rigorous curriculum, a well-defined set of high-level skills and processes, desirable attitudes and beliefs, and appropriate tools, while also considering the various contexts in which Filipino learners learn.

The content of the curriculum is clustered into five strands, namely,

1) Numbers and Number Sense,
2) Measurement,
3) Geometry,
4) Patterns and Algebra, and
5) Statistics and Probability.

In each of these major strands, critical thinking and problem-solving skills must be embedded for them to be developed sustainably among Filipino learners.

For Statistics and Probability, it includes the following domains which is the focus of this study:

1) skills in data collection,
2) organization, and
3) interpretation,

Including making predictions about outcomes. Each domain has content and performance standards and competencies that are developed spirally to help students master the desired skills as they go to higher levels of learning.

The curriculum also encourages the development of specific skills and processes among Filipino learners, such as knowing and understanding, estimating, computing, and solving, visualizing and modeling, representing and communicating, conjecturing, reasoning, proving and decision-making, and applying and connecting. Values and attitudes are also important to be honed by the students with the guidance of the school in general, and the teachers in particular.

Moreover, the framework in Mathematics is supported by learning principles and theories like

1) Experiential and Situated Learning,
2) Reflective Learning,
3) Constructivism,
4) Cooperative Learning and Discovery, and
5) Inquiry-based Learning.

The Mathematics Curriculum is grounded on these theories and is necessary upon the realization and attainment of its goals to develop the critical thinking and problem-solving skills among Filipino learners.

In conclusion, the Mathematics Curriculum offers a firm foundation for students as they pursue their higher education; thus, in acquiring the essential concepts and life skills provided by the curriculum, Filipino learners are being equipped and trained to be ready to face the challenges of the 21st century. On the other hand, learners who practice critical thinking and creativity in solving a problem will likely be in demand to industries especially that employers are interested in accepting graduates of the K to 12 curriculum who possess these skills. It is believed that students who have the creative ability to solve a problem can produce a good quality of work (Amran, Kutty, & Surat, 2019).

Therefore, the education sector needs to seriously consider the development of critical thinking and problem-solving skills among Filipino learners so that, in the long run, the twin goals of Mathematics will be realized.

Performance Task Assessment
In the K to 12 Curriculum

Assessment is a very important component of the teaching-learning process because teachers, administrators, and officials in the education sector use it in devising interventions that could help learners to better comprehend and understand lessons. In many cases, teachers are using the paper pencil test in their assessment during face-to-face instruction, however due to the advancement of technologies and changes in the curriculum, teachers also leaned to adapt with these changes and were able to adjust their assessment strategies.

With the implementation of R.A No. 10533, also known as the Enhanced Basic Education Act of 2013 or the K to 12 curriculum, the Department of Education ordered the issuance of DepEd Order No. 8, s. 2015, also known as the Policy Guidelines on Classroom Assessment for the K to 12 Basic Education Program. In this order are the three components of summative assessment, namely, Written Works (WW), Performance Tasks (PT), and Quarterly Assessment (QT) which serve as bases of teachers in computing grades of learners in any subject area of different grade levels. In particular, 40% from the total grade of learners in Mathematics is computed in their performance task. This indicates that performance tasks are very essential in the acquisition of skills expected to be mastered by the learners and in the development of their conceptual understanding.

Also, during the pandemic, the Department of Education issued a DepEd Order (DO) no. 31, s. 2020, known as Interim Guidelines for Assessment and Grading in Light of the Basic Education Learning Continuity Plan which indicated that 50% of the final grade of the Junior High School (JHS) students in Mathematics will be taken from their performance tasks. It means that teachers should not take this for granted, instead, they must innovate, sustain and make performance tasks inhibit the goals of learning.

Performance task is one of the learning assessments, whereby learners are given opportunities to perform and demonstrate their knowledge, understanding and proficiency in a certain topic in order to yield a tangible or intangible outcome. If it is compared to a multiple-choice assessment wherein students shall select from given alternatives and choices, performance task is different because it presents situation that learners shall apply their learning to a certain topic discussed in the classroom. Darling-Hammond and Adamson (2010) stressed that performance task is an avenue for teachers to gather an output or evidences in pursuit to their knowledge gained from the learning and teaching process. Instead of monopolizing the discussion or using the answer-question method, performance task will be done in order for the students to apply their knowledge to new phenomenon or to design a solution to answer a certain concern or problem related to the lesson.

Literatures highlighted several advantages of performance assessment. Performance task 1) recognizes that students can express what they know and what they can do in many different ways, 2) provides opportunity to evaluate progress as well as performance, 3) involves students in process of assessing their own growth, 4) gives opportunity to establish a framework for observing students that is consistent with the principles of student's development, 5) contributes to meaningful curriculum planning and design of developmentally appropriate educational interventions, and lastly 6) opens avenue

for teachers to collaborate with their colleagues, thus enhancing teacher own professional skills (Sumiyati, 2012).

To conclude, as people are now in the 21st century, innovations on assessment must be given an utmost attention in order to keep abreast on the recent trends in education. Instead of measuring only students' performance, teachers must also create an opportunity for the learners to learn through the process. Not only students' learning assessment will be given consideration, but also feedback that teachers will get is far richer than the traditional form of assessing learners (Wei, Schultz, & Pecheone, 2012).

Design Thinking Process

A dramatic shift and change in education are sweeping through schools, especially during the pandemic. The birth of online class and virtual classroom are some of the reasons why teachers need to understand the nature of education. Learners are also improving because of their inclination to technology. These are some evidence that learners nowadays demand an era, whereby educators need to meet their needs inside of the classroom. More than that, they are proficient of immersing themselves in a wider dimension of education. With the world literally at their fingertips, today's students need teachers and administrators to re-envision the role of technology in the classroom.

That is why, one of the new trends of classroom learning is to engage learners in design thinking. The goal of design thinking is to improve and foster students with people-oriented attitude and a deep rooted and mastery of skills (Cassim, 2013). Through this goal, learners have the ability to process understanding the desired learning outcomes with redefining or implementing to a certain group or organization.

Interestingly, design thinking has different processes observed and defined by different scholars and researchers. Linton and Klinton (2019) described design thinking as fundamentally concerned with human needs and solving problems. Design thinking is a non-linear process, however, it is circular that happens between three different spaces, namely, 1) inspiration, 2) ideation, and 3) implementation (Buchanan, 1992). Inspiration encourages a person to search for solution to a given problem while ideation has a link or parallel with brainstorming. Moreover, in the ideation phase, ideas are being generated and developed that could lead to answer a problem or provide solution to a given phenomenon. In the implementation stage, executing and implementing the solution to the intended target user is needed for a wide use of the result. All projects must go through these three spaces. In addition, projects maybe repeatedly observed and tested in the inspiration and ideation spaces before its full implementation.

Meanwhile, Verma (2020) stressed that design thinking can also be viewed as a human-centered approach to creative problem solving. It means that through design thinking, students can find solutions to real life problems using their innate creativity and innovative minds. It has also the power to generate new product-based ideas and services like mobile application that solves problems, technology, break barriers, explore the unexplored and undiscovered ideas to unveil imagination and creativity.

Design thinking is a series of steps to solve a problem and it has three (3) elements: user needs, technology, and business advantage (Linton & Klinton, 2019); and a human-centered innovation process that are in line with observation, teamwork, quick learning, idea visualization, rapid concept prototyping, and concurrent business analysis (Lockwood, 2009). Based on Simon's Design Thinking Process stages, several other models have been crafted like the design produced by the Institute of Design at Stanford, also known as d.School. This approach has two main phases: 1) problem, and 2) solution. In the problem phase, observing and expressing one's opinion are being observed. While in the solution phase, it consists 1) Ideation, 2) Prototyping, 3) Testing. These approaches are directly and indirectly linked between the phases (Efeoglu *et al.*, 2013).

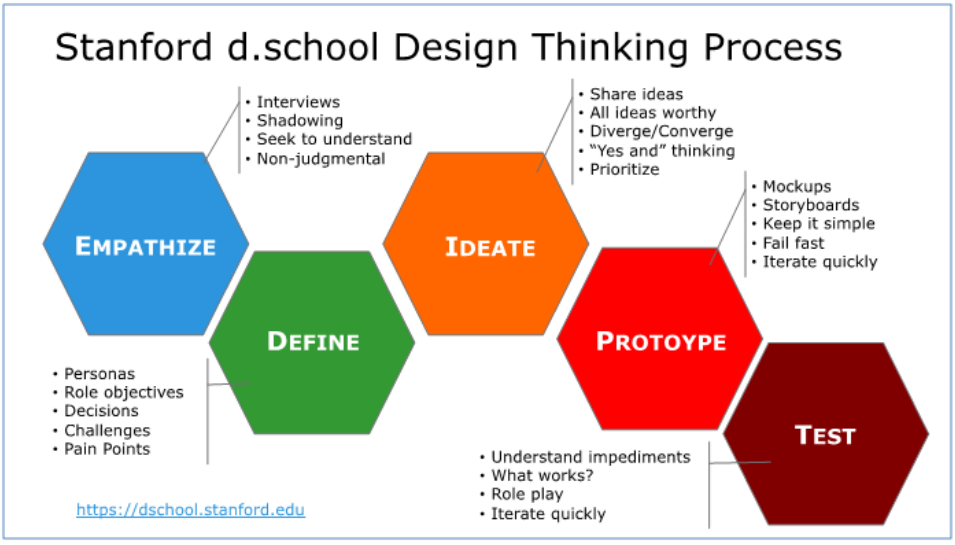

Figure 1: Design Thinking Process

As shown in Figure 1, the Institute of Design adapted its previously worked out scheme of the Design Thinking Process in 2009 to 2010 which consists of 5 different modes, namely, 1) empathize, 2) define, 3) ideate, 4) prototype, and 5) test. Empathizing is the beginning of the design process which comprises with different three (3) activities: 1) observation of users' behavior, 2) engagement-interacting with interviewing users, and 3) Immersion-experiencing what the user experience. Next is the defining mode which is connected to the actionable problem statement, while the ideation mode is focused on the generated idea. Creating ideas and explorations into the physical world are the target of the prototype mode. On the other hand, improving and refining the solutions to phenomena are the concerns of the fifth mode which is test (Plattner *et al.*, 2010).

According to the Institute of Design at Stanford, the empathize and define phases require students to determine people's needs and insights. Meanwhile, the ideation phase allows students to brainstorm ideas. It gives them time to provide varied solutions to a given problem. Many students learn to fail in the prototyping phase while in the purpose of testing, there will be a time to practice and improve the given solutions with feedback coming from the students themselves (Taking Design Thinking to Schools, n.d.).

Furthermore, Andrews (2019) pointed out that educators from Stanford University were focused on building the capacity of their students on learning and solving problems outside the formal classroom and they embraced design thinking strategies as a promising approach. According to him, design thinking can foster brainstorming and skills in collaboration which are valuable. The process and steps allow the participants to analyze, diverge and generate different insights from different domains through strategies like drawing, prototyping and storytelling (Panke, 2019). In addition, Panke (2019) emphasized that the core element of design thinking is to engage people in an environment that encourages risk-taking, civic mastery, civic literacy, and the ability to think critically and operate like an expert designer. On the other hand, Johanson and Woodila (2009) stressed that design thinking originated from architecture, design, art and management. This term has been known also for thirty (30) years in the academic sector and initially associated with how the designers think. In 1987, this term was used by Rowe in his book titled "Design Thinking", but in 1969, Simon analyzed the nature of the design before design thinking had been introduced (Luka, 2014). From then on, different models have been created that are based on theories, and models from design methodology, psychology, education, etc. were created (Dorst, 2011). According to Luka (2014), one of the prominent models of the Design Thinking Process was introduced by Simon in 1969 with seven (7) stages, namely, 1) define, 2) research, 3) ideate, 4) prototype, 5) choose, 6) implement, and 7) learn, as shown in Figure 2.

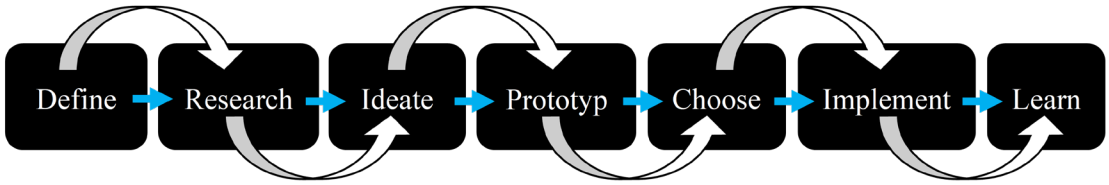

Figure 2: Herbert Simon's Seven (7) Stages of Design Thinking Process

In Simon's model of design thinking, it is necessary to define issues to be solved as an initial step. Next, research has to be conducted and brainstorming is needed to ideate solution. Moreover, it is necessary to expand, integrate and polish ideas to create a prototype for the intended users. Also, after prototyping, there is a need to review the objectives that are being targeted. Lastly, the execution or implementation of the outcome is needed so that there are still room for improvement and commendations for learning to take place.

The Design Thinking Process was also perceived as circular in nature (Efeoglu *et al.*, 2013). In 2006, Dunne and Martin emphasized the cyclical character of design thinking. As shown in Figure 3, it comprises different phases such as 1) induction, 2) abduction, 3) deduction, and 4) testing. Interestingly, scholars like Brown in 2008 also claimed that the Design Thinking Process is also circular in nature and has three spaces, namely, 1) inspiration, 2) ideation, and 3) implementation.

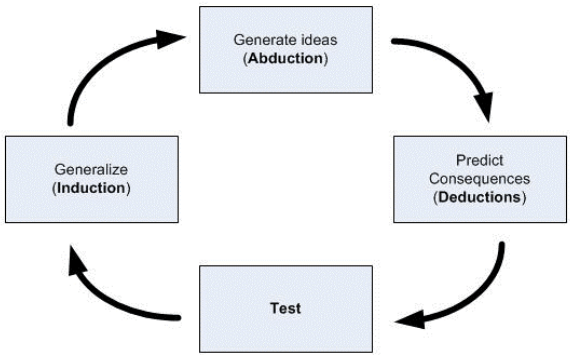

Figure 3: Dunne and Martin's Cyclical Model of Design Thinking

Based on the article of Luka (2014), there are several other models of the Design Thinking Process that have been created and some of them even used the same terminology. But, the most notable of them is the

model introduced by the Institute of Design at Stanford University.

Design thinking in education is sometimes referred to as design-based learning. It provides a way to improve students' performance in terms of originality, perseverance, involvement, and innovation (Dolak *et al.*, 2013). It helps students collaborate effectively across disciplines and bring about positive, design-led change in the world. It is a problem-solving technique that addresses common issues and concerns that is focused on highly proceedings, learning and knowledge creation in design thinking education (Luka, 2014).

Design thinking skills can be developed through a variety of activities at school, particularly group work and projects, as one of the requirements for teamwork and effective discussions. Numerous options have been tested by practitioners. Ray (2012) suggested working in a group or "collabs" by having the following six (6) steps: 1) identify opportunity; 2) design; 3) prototype; 4) get feedback; 5) scale and spread; and 6) present. Meaning, these six (6) steps offer learners to solve a certain problem that could require them to use their critical thinking and problem-solving skills. These steps also demonstrate small changes that can greatly impact results particularly in letting learners to express their decisions to agree or disagree to a certain idea. This is done in order not to discourage other learners in expressing their opinion and search alternative ideas which is essential in building prototypes.

Identify Opportunity

The need why the problem needs to be solved and who will benefit from the answers or solutions to the problem will become clear to students during this stage. Then, it is advised to select those who have encountered the problem firsthand and hear from them. Also, students will participate in several key informant interviews.

Design Process

During this phase, students shall review the different stories or ideas which they have gathered during the first step. After this, brainstorming will happen. They may use sticky notes and pen and let them brainstorm solutions. After finishing this, identifying main themes will be the next thing to be done and they need thorough research on initial ideas.

Prototype

The next step will be reviewing the ideas and choosing one prototype that could solve one respect to the problem. Brainstorming map will be done in order to picture the thinking process and it will be served as guide in going to the next step.

Feedback

On this stage, the groups will present their solutions to external experts for feedback that has the capacity and knowledge about the problem or issue. Two experts from different stakeholders groups.

Scale and Spread

Students continue to work in groups during this phase to come up with the best response to the criticism received during the previous phase. To assist students in making a wise selection at this time, the teacher's assistance and direction must be used. If the group receives conflicting advice from the experts, it may break up into smaller groups, with each group focusing on a different problem. In order to prepare for the presentation, the sub-groups then gather together and decide on a common option.

Present

The groups present their problem-solving strategies. People whom the students interviewed in the initial phase may be invited to make the process more significant for them.

In connection, these steps need timeline for the students to follow. It is an avenue for them to solve real life situations and offer a problem-solution to be utilized by a group of people in a community. It is somewhat similar to redefinition, whereby, outputs of the learners will be shared in the community to solve a certain phenomenon. The challenge of the teacher is the availability of time because engaging on these steps cannot be done in one sitting only, perhaps it needs a lot of time and days before coming to favorable solutions.

Basically, design thinking is also applicable in teaching Mathematics. Problem-based learning and design thinking (DT) tasks, according to Köroğlu and Yıldız (2021), instruct students on the problem they want to solve and allow them to use critical thinking and problem-solving skills to garner a solution. In Mathematics education, implementing strategies that deliberately enforce the DT approach in mathematics classes may have a positive impact on students' approaches to difficult problems (Chin *et al.*, 2019).

Design Thinking-based Lesson Plans (DTLPs)

With the increased attention on assessment in the K to 12 Curriculum comes a surge of interest in designing performance-based tasks. Designing and using performance tasks provide avenue to educators to teach, monitor, and extend student learning.

According to National Science Teaching Association (2022), there are different points to consider in designing a performance task and they are the following:

1) unpack the performance expectation by digging what are the necessary competencies;

2) identify rich and authentic phenomena that fits the performance expectation;

3) develop prompts by carefully making of different questions and instructions that the students will answer;

4) create scoring guides or rubrics aligned to the dimensions on the prompt or questions; and

5) pilot to students with the appropriate grade level, score students' responses, and revise prompts and questions based from their scores.

Meanwhile, Albay and Eisma (2021) concluded in their study titled Performance Task Assessment supported

by the Design Thinking Process: Results from a true Experimental Research that incorporating design thinking principles into the teaching and learning process, particularly in the area of performance task assessment, can help students develop their creativity through empathy, collaboration, and non-linear problem solving. This is supported by the study of Sener *et al.* (2015), claiming that using design thinking principles in the classroom can also help students develop creative thinking skills.

Therefore, the incorporation of the process of design thinking in the performance task evaluation helped learners in acquiring pertinent knowledge, abilities, concepts, and frameworks that serve as the basis for structuring their strategies on the task they are assigned (Albay & Eisma, 2021). Additionally, as a result of their study, the experimental group's performance on the performance task suggests that design thinking can significantly enhance the possibility of a 21st-century classroom that effectively responds to RA 10533 and the Policy Guidelines on the K–12 Basic Education Program of the Philippines (DepEd Order No. 21, s. 2019).

Moreover, Simon and Cox (2019) emphasized the findings of their narrative investigation into the effects of prototyping and design on the processes on mathematical modelling into the lens of design thinking, the impact of mathematization on research conducted in classrooms and mathematics education, and the experience-driven game design techniques which encouraged students to reflect on their regular mathematics encounters.

Indeed, incorporating design thinking principles provides educators with appropriate support to facilitate a constructivist approach to teaching and learning that meets the demands of 21st century education. The incorporation of design thinking stages into various aspects of the teaching and learning process can help students learn necessary skills such as cooperation, logical analysis, communication, and creativity while aiming to satisfactorily complete the requirements of the given task (Albay & Eisma, 2021).

Finally, educators are challenged to provide students with the necessary competencies and skills to meet the demands of the 21st century learning environment. As a result, educators must switch from imparting knowledge to helping students reach their full potential by implementing effective teaching and learning strategies such as design thinking. This means that educators should give learning opportunities that provide students the chance to plan, reflect, interpret various pieces of information, and use information effectively to solve problems.

MATERIALS AND METHOD

Locale of the Study

The study was conducted at the Diocese of Laoag Catholic Educational System (DLCES), involving eleven (11) member schools, namely, 1) Immaculate Conception Academy, 2) Holy Spirit Academy of Laoag, 3) Sta. Rosa Academy, 4) St. Joseph Institute of Dingras, Inc., 5) St. Joseph High School-Laoag, 6) St. Anne Academy of Piddig, 7) St. Andrew Academy of Bacarra, 8) St. James Academy of Pasuquin, 9) St. Nicholas Academy, 10) St. Jude High School of Pagudpud, and 11) St. Lawrence the Deacon Academy.

The Diocese of Laoag Catholic Educational System is presently headed by Bishop Most Rev. Renato P. Mayugba D.D., together with the DLCES School Superintendent Rev. Fr. Tito Romeo Bonoan. DLCES has fifteen (15) member schools including elementary catholic schools in the entire province of Ilocos Norte, Philippines. Notably, the institution is envisioned as creative, Christ-centered, and Catholic, committed to renewing persons into becoming authentic witnesses engaged in the service of the Church and society. Thus, the integration of effective teaching and learning strategies such as Design Thinking is needed to upbring creativity, innovative skills, empathy, Christian attitudes and values among learners.

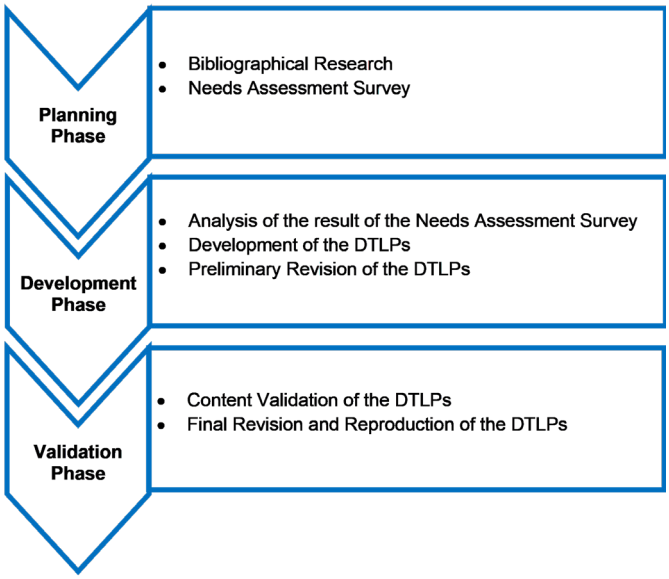

Figure 4: Schematic diagram showing the steps in the development of the Design Thinking-based Lesson Plans (DTLPs)

Research Design

The study used the descriptive research design, incorporating the Research and Development (R & D) methodology. As shown in Figure 4, the study was conducted in three (3) phases of R & D methodology such as, 1) Planning Phase, 2) Development Phase, and 3) Validation Phase.

The Planning Phase includes identification of strategies suited to each phase of design thinking essential in crafting lesson plans that cover the competencies of Statistics and Probability that need performance tasks as perceived by Grade 7 Mathematics teachers. Moreover, it also covers study of literatures relevant to the research, specifically on the implementation of the K to 12 curriculum and on the attainment of the twin goals of Mathematics (critical thinking and problem-solving skills) among Filipino learners.

The Development Phase includes the development of the Design Thinking-based Lesson Plans (DTLPs) based on the analysis of data on the needs assessment survey particularly on the competencies that need performance tasks. The developed material underwent thorough checking and revision by the research adviser and members of the advisory committee.

Lastly, the developed DTLPs were subjected to final validation in terms of content, instructional and assessment characteristics by a panel of experts in the Validation Phase. Before the material was reproduced, it was revised and improved integrating the experts' remarks and suggestions.

Population and Sampling Procedure

In the conduct of the study, two sets of respondents were involved. The first set includes eighteen (18) Grade 7 Mathematics teachers from the (11) member schools of DLCES who were purposively chosen based on their field of interest, expertise, and availability to answer the needs assessment survey.

The second set includes ten (10) validators from the Schools Division of Ilocos Norte (SDOIN), and Mariano Marcos State University (MMSU). They are composed of four (4) experts in design thinking, three (3) Mathematics specialists and three (3) experts in instructional materials preparation who did the content validation of the DTLPs. The researcher employed the Purposive Sampling Procedure in selecting the validators. The four (4) experts in Design Thinking were chosen because 1) they are incorporating Design Thinking Process in educating students; and 2) they have been trainers or speakers of design thinking. On the other hand, the three (3) Mathematics specialists were chosen based on their 1) field of specialization; and 2) number of years in teaching Mathematics which is at least three years. Lastly, the three (3) experts in instructional materials preparation 1) had at least three years of teaching experience; 2) are members of the Quality Assurance Team of instructional materials; and 3) had developed and published an instructional material for the learners.

Conceptual Framework

To have a distinct view on the important details in the conduct of the research, and to visualize a clear picture of the study, the researcher used the Input, Process, and Output (IPO) Model. The IPO Model was utilized as basis in constructing a more detailed research paradigm showing the graphical representation of all the factors that make up the process of this study. Specific details are shown in Figure 5.

The K to 12 Mathematics Curriculum was one of the major inputs in this study, primarily on Statistics and Probability

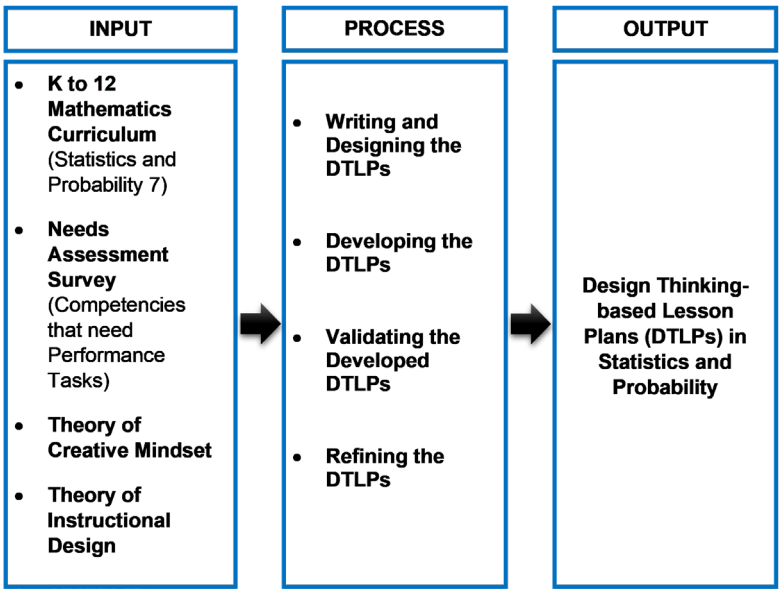

Figure 5: The research paradigm

7 topics. A needs assessment survey was conducted to provide insights on the learning competencies on Statistics and Probability 7 that need performance tasks. The Theory of Creative Mindset, and Theory of Instructional Design serve as guide in the conduct of the study. These inputs provided the researcher with the theoretical bases to develop the Design Thinking-based Lesson Plans (DTLPs).

The Process includes analyzing data results, designing, writing and developing the DTLPs. All concepts, designs and plans were finalized and executed in the development of the DTLPs incorporating various strategies aligned to the Design Thinking Process. The developed DTLPs were subjected to validation by a panel of experts. Their comments and suggestions were considered in the refinement of the material.

The Output of the study is the Design Thinking-based Performance Tasks (DTPTs) Plan in Statistics and Probability.

Data Gathering Procedure

Prior to the conduct of the study, the researcher accomplished the clearance from the University Research Ethics Review Board (URERB) of the Mariano Marcos State University (MMSU). Upon receipt of the clearance, the researcher conducted the study with the endorsement of the dean of MMSU-Graduate School. The initial preparations and introductory measures such as requesting for consent to conduct the study by means of formal communication letters were made. The letters were addressed to the concerned administrators of the Diocese of Laoag Catholic Educational System (DLCES), Schools Division of Ilocos Norte, and Mariano Marcos State University. While conducting the study the researcher followed strictly health protocols and research protocols.

Upon the approval of the DLCES School Superintendent to the request in conducting the study, a Needs Assessment Survey was administered among the Grade 7 Mathematics teachers to each member schools of the DLCES. The researcher distributed the Needs Assessment Survey online especially to the school principals of every catholic school for faster consolidation of data. For convenience and efficiency, the researcher used Google Forms to collect the responses of the teachers within the allotted time. The learning competencies that need performance tasks as perceived by the teachers were ranked. The top ten (10) learning competencies that need performance tasks were used as bases for the development of the Design Thinking-based Lesson Plans (DTLPs).

Moreover, as preparatory measures on the formulation of the DTLPs, the researcher had a thorough analysis and detailed exploration of reference materials (e.g. printed and non-printed) which aided the researcher to come up with the appropriate strategies, scheme, layout, procedures and means of finalization and refinement of the material.

In developing the DTLPs, the researcher followed the five phases of Stanford University's Design Thinking process, namely, empathy, define, ideate, prototype and test. Also, varied strategies were identified appropriate in each phase of design thinking. These strategies were carefully selected from the guidebook created by the IDEO, a design consulting company, focused on design research and education. However, the activities used in each phase were contextualized and problem-based aligned with the design challenges in the DTLPs.

The developed DTLPs were validated by a set of experts from the Schools Division of Ilocos Norte (SDOIN), and Mariano Marcos State University (MMSU) with the approval of the administrators of the said institutions. The copies of the DTLPs and the validation tool were given to the validators. Their comments and suggestions were used as bases for the improvement and final revision of the material.

Statistical Treatment of Data

The information gathered pertinent to this study were collated, tabulated and analyzed using frequency count, rank, percentage and means.

Frequency count, percentage and rank were used to determine the learning competencies in Statistics and Probability 7 that need performance tasks.

Mean was used to describe the ratings of the validators on the validity of the DTLPs. Results were interpreted using the range of means adapted from Balguna (2021) with their corresponding descriptive interpretations as follows: the range of means ranging from 4.50-5.00 indicates Highly Valid (HV), value from 3.50-4.49 indicates Valid (V), values from 2.50-3.49 indicates Moderately Valid (MV), values from 1.50-2.49 indicates Needs Improvement (NI), and values from 1.00-1.49 indicates Not Valid (NV).

RESULTS AND DISCUSSION

Learning Competencies in Statistics and Probability Needing Performance Tasks

This section presents the learning competencies in Statistics and Probability that need performance tasks which are reflected in the results of the Needs Assessment Survey. These learning competencies were identified based on the list of Grade 7 Statistics and Probability competencies prescribed by the K to 12 Mathematics curriculum. Only the top 10 learning competencies were used as bases in the development of the DTLPs. Moreover, a minimum of four (4) performance tasks must be administered within a quarter (DepEd Order No. 8, s. 2015 & DepEd Order No. 31, s. 2020). Thus, the researcher made six (6) DTLPs anchored on the identified learning competencies. Table 1 shows the results of the Needs Assessment Survey.

Table 1: Distribution of responses in the needs assessment survey

Unpacked Learning Competencies in Statistics and Probability 7	f	%	Rank
The learner…			
1. Explains the importance of Statistics.	13	72	7.5
2. Poses problems that can be solved using Statistics and formulates simple statistical instruments.	15	83	4
3. Identifies different ways of collecting statistical data.	9	50	10
4. Organizes data in a frequency distribution table and draws conclusion from the tabularized data	16	89	2.5
5. Uses bar graphs and histogram to represent and formulate conclusions about the organized data.	16	89	2.5
6. Uses pie chart to represent and interpret organized data.	6	33	13.5
7. Uses line graph to represent and interpret organized data.	17	94	1
8. Illustrates each measure of central tendency and explain its characteristics, use, advantages and disadvantages.	13	72	7.5
9. Calculates the mean, median and mode of grouped statistical data.	14	78	5.5
10. Calculates the mean, median and mode of ungrouped statistical data.	14	78	5.5
11. Analyzes and interprets statistical data using measures of central tendency.	12	67	9
12. Illustrates each measure of variability (range, average deviation, variance, standard deviation).	8	44	11
123. Calculates and draws conclusions from the measures of variability of grouped data.	7	39	12
14. Calculates and draws conclusions from the measures of variability of ungrouped data.	6	33	13.5

Table 1 reveals the top 10 learning competencies that need performance tasks as perceived by the teachers. First in rank is the competency that deals with the use of line graph to represent and interpret organized data. Two of the competencies tied up in rank 2.5 and those are the one that deal with organizing data in a frequency distribution table, and using bar graphs and histogram to represent and formulate conclusions about the organized data. Next in rank 4 is the competency that deals with posing problems that can be solved using Statistics and formulates simple statistical instruments. Also, there are two competencies that are both in rank 5.5, and one of them pertains to calculating the mean, median and mode of grouped statistical data, and the other is on calculating the mean, median and mode of ungrouped statistical data. Subsequently, the competency that deals with explaining the importance of Statistics, and illustrating measures of central tendency, are both in rank 7.5. In rank 9 is the competency that deals with analyzing and interpreting statistical data using measures of central tendency. Lastly, the competency on identifying different ways of collecting statistical data is in rank 10.

Notably, Statistics and Probability permit students to explore, compute, determine, find, and conduct statistical processes that are all necessary in fostering 21st century skills (Castillo, 2019). Thus, the learning competencies of the subject need the integration of the Design Thinking Process in order to provide learning opportunities that will immerse students to learn and develop necessary skills such as collaboration, critical thinking, problem solving, communication, and creativity.

Design Thinking-based Lesson Plans (DTLPs)

The Design Thinking-based Lesson Plans (DTLPs) were developed based on the identified top ten (10) learning competencies. Six (6) DTLPs were created, in which each one covers at most three (3) learning competencies. They are also contextualized and aligned with the five (5) iterative phases of design thinking, namely, 1) Empathize, 2) Define, 3) Ideate, 4) Prototype, and 5) Test, by the Institute of Design at Stanford University.

Immersing learners to design thinking contributes to the development of their creative thinking skills (Sener *et al*., 2015), and design thinking can provide a significant positive impact in facilitating a creative 21st century classroom that sufficiently address the demands of Philippine education (Albay & Eisma, 2021).

In fact, educators can promote a constructivist approach to teaching and learning that fits the demands of the 21st century education by applying the concepts of the design thinking process. Students can develop vital skills like collaboration, critical thinking, communication, and creativity by integrating the phases of the design thinking process into many areas of the teaching and learning process (Albay & Eisma, 2021).

The developed DTLPs offer educational chances for students to demonstrate and develop their 21st century skills. Alongside with creativity, problem solving, critical thinking, communication, and collaboration, student's ability to understand and feel other people's perceptions on a situation is also being enhanced. In addition, the material mirrors realistic conditions based on real-life problems, where students can pose possible solutions. Contextualization was integrated to each task and situation given to students for them to relate their own thoughts and experiences in ideating plans to create solution. Moreover, the integration of the lesson to other subject areas such as Science, Economics, English, and Information and Communication Technology (ICT), were highlighted in each task. The DTLPs expose the

need of applying knowledge from other subject areas in order for the students to realize the relevance of Statistics and Probability on a wider scope.

Furthermore, the DTLPs cover weekly lessons with the following parts: Objectives, Subject Matter, Learning Resources, Rubric, Overview of the Lesson, and Procedures. The objectives present the content standard, performance standard, competency, and learning outcomes in order to clearly state and describe behaviors, outcomes, skills or performance that the teacher intends to teach, exhibit and inculcate among learners. The subject matter includes the content or topic as the focus of the lesson. The learning resources contain the references and other resources used such as books, website, and modules. The rubric part provides holistic rubrics as bases in scoring or rating performances of the students. The overview of the lesson presents a brief description of the expected activities or tasks to be performed. Lastly, the procedures of the lesson plan utilize the five (5) stages of the Design Thinking Process namely: 1) Empathize; 2) Define; 3) Ideate; 4) Prototype; and 5) Test.

Salient Features of the DTLPs

The DTLPs have several attributes that are unique to other lesson plans. They were developed with significant features, such as, the incorporation of the Design Thinking Process, alignment to the K to 12 curriculum, contextualization of the activities, integration of activities to other learning areas, development of Higher Order Thinking Skills (HOTS), and sequential parts of the lesson.

Design Thinking Process

The DTLPs made use of the Design Thinking Process model by the Institute of Design at Stanford University which involves five (5) stages, namely, 1) Empathize, 2) Define, 3) Ideate, 4) Prototype, and 5) Test.

Three (3) templates are used in each of the first three stages of the Design Thinking Process. In the Empathize Stage, an Empathy Map Template is used to gain deeper insight of the thoughts, feelings, actions and words of the users, a way in which the students can put their feet on the shoes of others to be connected with them. In the Define stage, a Point of View (POV) Template is used to guide students to come up with actionable statements that are based on a deeper understanding of the specific user, their needs and the students' insights about them anchored on their outputs in the Empathize Phase. Meanwhile, in the Ideate Stage, a "How might we?" Template is used to help students brainstorm ideas for ideation sessions in which they learn to devise plans or solutions to problems.

Consequently, in the Prototype Stage, students are given opportunities to execute plans that they have identified in the previous stages. The output made in this stage will be checked in the Test Stage. Students are given opportunities to present their prototype and explain the things that they have done including their computations as an application of the concepts that has been discussed.

Alignment to K to 12 Curriculum

The development of the material was based on the K to 12 learning competencies in Mathematics specifically in Grade 7 Statistics and Probability. The learning presentation was properly arranged in chronological order following and incorporating the stages of the Design Thinking Process.

Each of the topics covered by the lesson were carefully planned with appropriate strategies to foster student's creativity, communication, collaboration, problem-solving and critical thinking skills. Performance task rubrics were also provided in the DTLPs. Thus, teachers are guided in assessing the performance and outputs of the learners.

Contextualization of the Activities

The activities were prepared based on real-life problems. Each lesson relates to meaningful experiences and situations of students that include environmental problems, Corona Virus Disease (COVID-19), earthquake, business related problems, and economical problems. In such way, students can learn to relate their own experiences, perceptions, and environment to their learning activities.

Integration of Activities with Other Learning Areas

Some of the activities are integrated with other subject areas such as Science, and Information and Communications Technology (ICT). Students are introduced with environmental problems, natural disasters, health issues, and economic problems in order to provide meaningful learning opportunities to students. In like manner, students are also given opportunities to use ICT concepts in Mathematics so that they can apply and realize the importance of the subject in a wider scope.

Development of HOTS

The learning tasks and guide questions are formed to develop Higher Order Thinking Skills (HOTS). Students are given learning opportunities to apply, analyze, evaluate, and create output in each plan. With the integration of the Design Thinking Process, the students are directed to foster these skills.

Sequential Parts of the Lesson

The DTLPs cover weekly lessons with the following parts: Objectives, Subject Matter, Learning Resources, Rubric, Overview of the Lesson, and Procedures.

Validity of the Design Thinking-based Lesson Plans (DTLPs)

This section presents the results of the validation made by the panel of experts on the developed DTLPs along content characteristics, instructional characteristics, and assessment characteristics.

Content Characteristics of the DTLPs

In developing learning materials, the content characteristics

must be suited and relevant to the skills which the teacher wants to develop among learners (Tumamao, 2016). Thus, expert groups were asked to validate the DTLPs along with its content characteristics in order to see its alignment to K to 12 curriculum, appropriateness to the level of students, and significance in enhancing skills needed by the learners. The data are shown in Table 2.

As shown in Table 2, the calculated overall mean rating

Table 2: Validity of the DTLPs along content characteristics

Criteria	Mean	Descriptive Interpretation
The DTLPs…		
1. Is clearly aligned to the learning competencies and to specific content standards being targeted.	4.9	HV
2. Contains clear performance outcomes, including the knowledge, behaviors, and skills, students are expected to demonstrate in the performance task(s).	4.5	HV
3. Is appropriate for the specified grade level.	4.3	V
4. rovides learning opportunities to develop and/or showcase student's 21st century skills.	4.8	HV
5. Mirrors realistic conditions based on real-life problems where students can pose possible solutions	5	HV
6. Exposes the need of applying knowledge from other learning discipline	4.2	V
matches the level of complexity (Depth of Knowledge level) indicated by the standards.	4.4	V
7. Addresses a crucial problem, significant concept, or skill that is relevant to the unit, course, or domain.	4.6	HV
8. Specifies exactly what the learner is expected to perform, produce, or demonstrate.	4.6	HV
9. Is reasonably be completed under the specified conditions and time limits	4.3	V
Overall Mean	**4.56**	**HV**

Legend:
Range of Means
4.50-5.00
3.50-4.49
2.50-3.49
1.50-2.49
1.00-1.49
Descriptive Interpretation
Highly Valid (HV)
Valid (V)
Moderately Valid (MV)
Needs Improvement (NI)
Not Valid (NV)

of the developed DTLPs on content characteristics is 4.56, which implies that it is Very Highly Valid in terms of content. This means that the prepared lesson and activities are sufficiently meaningful to deepen critical thinking and problem-solving skills of students. The result also signifies that the lessons and tasks can cater the needs of the 21st century learners as they are exposed with activities and learning opportunities good for the development of the desired skills in this era.

In particular, six (6) out of the ten (10) indicators are described as Highly Valid with ratings ranging from 4.5 to 5.0. This indicates that the material was clearly aligned to the K to 12 curriculum, contains clear performance outcomes that students are expected to demonstrate in the performance tasks, provides learning opportunities to develop 21st century skills, contextualized based on real-life problems, addresses an essential issue or key concepts, and directions on the expected tasks are clear to the students. Moreover, the other four indicators are described as Valid with ratings ranging from 4.2 to 4.4 which are close to highly valid. Thus, the scope, standards, substance, and depth of the content of the DTLPs are appropriate to the students and it is aligned to the learning outcomes reflected in the K to 12 curriculum.

The results support the findings of Ballesteros (2019) who concluded that in developing learning materials, the content of the curriculum and the processes involved in teaching and learning must always be related to the students. Hence, localization and contextualization of activities provide students a direct connection with their assigned tasks to their thoughts and experiences, which leads to the enhancement of their skills.

The validators acknowledged that the content of the DTLPs are aligned to the intended learning outcomes and the lessons were based on real-life situations. They also recognized that the DTLPs are logically developed and organized to cater the needs of the 21st century learners. Their remarks are as follows:

The DTLPs are aligned with the learning competencies that are being targeted. The DTLPs also addressed the intent/purpose of each DT phase.

-Validator 3

Congratulations! The content is appropriate and aligned to the students competencies and learning outcomes. The different Performance Tasks are designed for Higher Order Thinking Skills and 21st Century Skills of learners.

-Validator 5

Contents are logically developed and organized.

-Validator 7
The targeted learning competencies for the subject matter and grade level are tied to the content. The order of the topics and exercises in each session makes it easier to accomplish the goals. Logic is used to develop and organize the content.
-Validator 9
The content of the DTLPs is aligned with the learning competencies in the curriculum of Grade 7 mathematics. The DTLPs were based on the idea of contextualization and localization giving the students a better way of understanding the competencies. All the activities given are relevant and designed to develop Higher Order Thinking Skills.
-Validator 10
Meanwhile, there were several suggestions that have been incorporated into the revision of the DTLPs. The validators suggested that there should be tangible outcomes that should be created in the prototype phase of each lesson plan. Thus, the researcher worked for the refinement of the material and included tangible outputs such as research instrument, excel file, poster, brochure, meal plan, and reports. Their suggestions are as follow:
Some of the activities included in the Prototype phase must be improved.
-Validator 1
I suggest that "prototypes" be an Instructional Material, survey instrument, brochure, poster, and among others so that these could surely hit or include the practice/ enhancement of the 21st century skills among students.
-Validator 4

Instructional Characteristics of the DTLPs
Learning materials should be interesting and relevant so that students become more competent and active learners in pursuit to quality education. According to Lasaten (2012), instructional characteristics of any learning material should create curiosity, maintain focus, and introduce concepts in a logical order. Thus, to nurture the potentials of students, activities or lessons should encourage active participation in class so that learning becomes more meaningful. The results of the content validity of the DTLPs in terms of instructional characteristics are shown in Table 3.

Table 3: Validity of the DTLPs along instructional characteristics

Criteria	Mean	Descriptive Interpretation
The DTLPs…		
1. Heeds the application of knowledge and skills, not just recall or recognition of a concept.	5	HV
2. Encourages creativity and individuality among learners.	4.8	HV
3. Diminishes the notion that there is only one correct way of thinking or there is only one way of solving problems.	4.8	HV
4. Subjects the learners to a new situation where they can apply the concepts that they have learned.	5	HV
5. Involves multiple steps and standards to evaluate several learning targets.	4.7	HV
6. Provides for ownership and decision-making, requiring the student to be actively engaged.	4.9	HV
7. Provides clear directions/instructions to indicate and guide students on the task that they are being asked to do.	4.5	HV
8. Is fair and unbiased in language and design.	4.6	HV
9. Is free of stereotypes.	4.8	HV
10. Is free of irrelevant information and unusual words that students may not understand.	4.8	HV
Overall Mean	**4.79**	**HV**

Legend:
Range of Means — *Descriptive Interpretation*
4.50-5.00 — *Highly Valid (HV)*
3.50-4.49 — *Valid (V)*
2.50-3.49 — *Moderately Valid (MV)*
1.50-2.49 — *Needs Improvement (NI)*
1.00-1.49 — *Not Valid (NV)*

As reflected in its overall mean of 4.79, the material's instructional characteristics is described as Highly Valid. All the specific indicators under instructional characteristics are described as Highly Valid with numerical ratings ranging from 4.5 to 5.0, in which two of the indicators were given a perfect rating of 5.0.
The results presented indicate that the structure and organization of the DTLPs include learner support, student engagement, clarity and fairness of instruction, interactivity, and various learning opportunities. This relates with the findings of Avila (2020) who concluded that exposing students with the phases of Design Thinking (DT) enables

them to show their creativity in coming up with solutions to the design challenge in real-world settings, to investigate problems over a sustained period of time, and to collaborate with peers in looking for solutions.

The validators acknowledged that the instructional characteristics of the DTLPs are focused on the diversity of learners, and the instructions are clear and easy for the students to understand. Their remarks are as follow:

The instruction is centered on what the students know, understand, and can do in daily lesson. It facilitates opportunities for students to be metacognitive. It also focuses on higher order thinking for the students.
-Validator 8

The directions are clear and easy to follow and understand.
-Validator 5

Congratulations! Your DTLPs Instructional Characteristics are commendable. The words used are simple and easy to understand. General directions are properly written and easy to understand.
-Validator 6

Meanwhile, some of the validators suggested essential revisions of the DTLPs along with its instructional characteristics. The provided instructions per activities were improved accordingly. Also, there were identified grammatical errors of the DTLPs that have been corrected and its formatting was modified as well. Their suggestions are as follow:

The Empathy Map, POV, and 'How Might We' Templates are great! However, directions to these activities must be improved. Please rephrase the directions.
-Validator 2

Simplify complex sentences for clearer instructions. Observe uniformity and consistency in format and emphasis of salient points. Check spacing between paragraphs as well as tables.
-Validator 4

Assessment Characteristics of the DTLPs

One of the important components of instructional material is assessment. Ideal authentic assessments give students the chance to demonstrate their knowledge in different contexts (Farell, 2020). It is where the teacher can measure and identify how deep is the understanding of the learners on the concepts tackled. Thus, the DTLPs were validated accordingly with its assessment characteristics.

Table 4 shows the results of the validation of the material along assessment characteristics. The assessment characteristics of the DTLPs were rated as Highly Valid as shown by its overall mean rating of 4.6.

Interestingly, all the indicators were evaluated as Highly Valid with numerical ratings ranging from 4.5 to 4.7. This shows that the qualities of the DTLPs in assessing students' learning are well-established in which the desired learning outcomes and skills are mastered based on pertinent criteria.

Consequently, the results presented above are supported by the DepEd Order No. 21, s. 2019, also known as Policy Guidelines on the K to 12 Basic Education Program whereby it is highlighted from the said order that the K to 12 curriculum shall employ pedagogical approaches that are constructivists, inquiry-based, reflective, collaborative, differentiated, and integrative. Thus, performance task assessment is being utilized to evaluate students' learning and skills in accomplishing practical, tasks especially in dealing with real-life problems.

Table 4: Validity of the DTLPs along assessment characteristics

Criteria	Mean	Descriptive Interpretation
The DTLPs…		
1. Has a clear and well-established scoring rubrics/guideline with relevant criteria.	4.5	HV
2. Helps students to track their own progress and reflect from their own learning.	4.6	HV
3. Provides feedback to students as part of the assessment process.	4.6	HV
4. Assesses what is intended to be assessed–elicits what the student knows and can do related to the chosen standards and benchmarks.	4.7	HV
5. Is feasible within the specified setting.	4.6	HV
Overall Mean	**4.6**	**HV**

Legend:

Range of Means	*Descriptive Interpretation*
4.50-5.00	*Highly Valid (HV)*
3.50-4.49	*Valid (V)*
2.50-3.49	*Moderately Valid (MV)*
1.50-2.49	*Needs Improvement (NI)*
1.00-1.49	*Not Valid (NV)*

The validators mentioned that the DTLPs provide detailed standards that teachers may use to assess how well the students are learning the intended competencies in Statistics and Probability. Their remarks are as follow:

Congratulations! There is a ready-made scoring rubric. You did a great job on making Performance Task for Design Thinking. Keep up the good work sir!
-Validator 5

Assessments are designed with the specific objectives and contents. Good job!
-Validator 7
The plan provides useful measures and information that help the teacher evaluates learner's progress in mastering the competencies.
-Validator 9
Meanwhile, some of the validators suggested essential revisions of the DTLPs along with its assessment characteristics. The provided rubrics were improved in accordance with their suggestions. Different rubrics are provided in every lesson plan as well. They are all aligned with the expected learning outcomes and performances of the students.
In summary, the validators affirmed that the DTLPs are indeed highly valid instructional material that can be used in promoting quality education. This material could also be of great help to improve the declining performance of Filipino learners in different international assessments in Mathematics. Furthermore, in response to the mandate of the K to 12 curriculum, the material was validated to be effective in delivering lessons in Statistics and Probability. Thus, the 21st century skills of Filipino learners are to be fostered, making them ready for entrepreneurship, employment, vocational courses, and higher education.

CONCLUSIONS

Based on the study's findings, it can be concluded that the top ten (10) learning competencies in Statistics and Probability that need performance tasks were identified. Based on these learning competencies, the design thinking-based lesson plans (DTLPs) were developed. After the conduct of the content validation of the DTLPs along with its content, instructional and assessment characteristics, the panel of experts concluded that the DTLPs are Highly Valid in all of these characteristics. The researcher highly recommends utilizing the developed DTLPs in an actual classroom setting, specifically in teaching Statistics and Probability to Grade 7 students in order to foster their skills and hone their interest in learning Mathematics. Likewise, to equip teachers with essential knowledge and skills on the development of Design Thinking-based Lesson Plans (DTLPs), school administrators are recommended to conduct intensive seminars, trainings, and workshops specifically for them in their in-service trainings and Learning Action Cell (LAC) sessions. Curriculum developers and policy makers are also advised to consider reforms on the curriculum and integrate the Design Thinking Process (DTP) to lessons particularly in performance tasks to enrich the curriculum, which will eventually provide learning opportunities to students to innovate and develop empathy, creativity, collaboration, problem solving skills, and critical thinking skills. Finally, similar or related studies should be conducted to investigate empirically the use of the DTP and DTLPs in other learning competencies in Statistics and Probability and other branches of Mathematics as well.

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REFERENCES

Albay, E. & Eisma, D. (2021). Performance task assessment supported by the design thinking process: Results from true experimental research. www.elsevier.com/locate/ssaho

Alonsabe, O. (2018). Deterioration of the Philippine education. https://olgasyscurriculum.blogspot.com/2018/04/deterioration-of-philippine-education.html

Ambag, R. (2018). Teaching Science in the Philippines: Why (and how) we can do better. https://www.flipscience.ph/news/features-news/features/teaching-science-philippines/

Amran, M. S., Kutty, F. M., & Surat, S. (2019). Creative Problem-Solving (CPS) skills among University students. *Creative Education, 10,* 3049-3058. https://doi.org/10.4236/ce.2019.1012229

Andrews, E. (2019). Will design thinking strategies benefit students after class is dismissed? https://ed.stanford.edu/news

Avila, A. C. (2020). Exploring design thinking-based lessons on DRRR for creative confidence and creative competence. Mariano Marcos State University.

Balguna, P. (2021). Socio-scientific issue-based lessons in Physics (SSIBLP). Mariano Marcos State University.

Ballesteros, J. (2019). Localization and contextualization of Science activities in enhancing learners' performance.

Capas Integrated School. https://www.academia.edu

Buchanan, R. (1992). Wicked problems in design thinking. *Design Issues, 8*(2), Spring 5-21.

Cassim, F. (2013). Hands on, hearts on, minds on: Design thinking within an education context. *International Journal of Art & Design Education, 32*(2), 190–202.

Castillo, C. (2019). A technology-enhanced instructional material to enhance conceptual understanding of students in Statistics and Probability. Mariano Marcos State University.

Center for Collaborative Education (2012). Assessment validation checklist. https://www.cce.org/uploads/internal/documents/Tool1_rev2_enabled_1.pdf

Chin, D. B., Blair, K. P., Wolf, R. C, Conlin, L. D., Cutumisu, M., Pfaffman, J., & Schwartz, D. L. (2019). Educating and measuring choice: A test of the transfer of design thinking in problem solving and learning. *Journal of the Learning Sciences, 28*(3), 337–380. https://doi.org/10.1080/10508406.2019.1570933

Collins, M. (2019). Design thinking is a challenge to teach and that's a good thing. https://www.edsurge.com/news/2019-07-31-design-thinking-is-a-challenge-to-teach-and-that-s-a-good-thing

Darling-Hammond, L., & Adamson, F. (2010). Beyond the bubble test: How performance assessments support 21st century learning. John Wiley & Sons.

DepEd (2016). K to 12 Curriculum Guide in Mathematics. http://lrmds.deped.gov.ph/.

DepEd Order no. 21 s. (2019). Policy guidelines on the K to 12 basic education program. https://www.deped.gov.ph/wp-content/uploads/2019/08/DO_s2019_021.pdf

DepEd Order no. 31 s. (2021). Interim guidelines for assessment and grading in light of the basic education learning continuity plan. https://www.deped.gov.ph/wpcontent/uploads/2020/10/DO_s2020_031.pdf

Dolak, F., et. al, (2013). Design thinking and design Science research. Institute of Information Management, University of St. Gallen, HSG/IWI,1-11.

Dorst, K. (2011). The core of design thinking and its application. *Design studies, 32*(6), 521-532. https://doi.org/10.1016/j.destud.2011.07.006.

Efeoglu, A., et. al, (2013). Design thinking characteristics and promises. Proceedings of 14th International CINet Conference on Business Development and Co-creation. *Enschede: Continuous Innovation Network* (CINet), 241-256.

Farell, C. (2020). Do international marketing simulations provide an authentic assessment of learning? A student perspective. *The International Journal of Management Education*. https//www.sciencedirect.com/science/article/abs/pii/S1472811719301612

Hess K. (2009). Local assessment toolkit. https://www.cce.org/uploads/internal/documents/Tool1_rev2_enabled_1.pdf

Johansson, U., & Woodilla, J. (2009). Towards an epistemological merger of design thinking. Robert Gordon University, Aberdeen, Scotland.

Kelly M. (2019). Authentic ways to develop performance-based activities. https://www.thoughtco.com/ideas-for-performance-based-activities-7686

Köroğlu, M. and Yıldız, B. (2021). Design thinking in Mathematics education: The Minecraft case. file:///C:/Users/Acer/Downloads/Design-Thinking-in-Mathematics-Education-The-Minecraft-Case.pdf

Lasaten, R.C.S. (2012). Information and Communication Technology-based resource kit in teaching Poetry. Mariano Marcos State University.

Linton, G. & Klinton, M. (2019). University entrepreneurship education: A design thinking approach to learning. *Journal of Innovation and Entrepreneurship, 8*(3), 1-11.

Lockwood, T. (Ed.). (2009). Design thinking: Integrating innovation, customer experience, and brand value. Allworth Press.

Lockwood, T. (Ed.). (2009). Design thinking: Integrating innovation, customer experience, and brand value. New York, NY: Allworth Press.

Luka, I. (2014). Design thinking in pedagogy. *Journal of Education and Society, 2*(1), 63-74.

Lund, J. & Kirk, M. F. (n.d.). Advantages of using performance-based assessments. https://us.humankinetics.com/blogs/excerpt/learn-the-advantages-of-using-performance-based-assessments

McTighe, J., *et al.*, (2020). Designing authentic performance tasks and projects: Tools for meaningful learning and assessment. Alexandria, VA: ASCD.

National Science Teaching Association (2022). How to design a performance task. https://www.nsta.org/how-design-performance-task

Panke, S. (2019). Design thinking in education: Perspectives, opportunities and challenges. Open Education Studies. https://doi.org/10.1515/edu-2019-0022

Plattner, H., *et al.*, (2010). Design thinking: An educational model towards creative confidence. Proceedings of the 1st International Conference on Design Creativity (ICDC 2010), Kobe, Japan, 11, 2010, 1-8.

Polya G. (1945 & 1962). Polya's problem solving techniques. https://math.berkeley.edu/~gmelvin/polya.pdf

Ray, B. (2012). Design thinking: Lessons for the classroom. http//www.edutopia.org/blog/design-thinking-betty-ray

Reigeluth, C. M., & Carr-Chellman, A. A. (2009). Understanding instructional theory. In *C. M. Reigeluth & A. A. Carr-Chellman (Eds.), Instructional-design theories and models: Building a common knowledge base* (Vol. 3, pp. 3–26). Routledge.

Republic Act No. 10533 (2013). An act enhancing the Philippine basic education system vy strengthening its curriculum and increasing the number of years for basic education, appropriating funds therefor and for other purposes. https://www.officialgazette.gov.ph

Scriven M., & Paul, R. (1987). Critical thinking as defined by the national council for excellence in critical

thinking. https://www.criticalthinking.org/pages/defining-critical-thinking/766

Sener, N., *et al*., (2015). Improving science attitude and creative thinking through science education project: A design, implementation and assessment. *Journal of Education and Training Studies, 3*(4), 57-67.

Simon, L., *et al*., (2019). The role of prototyping in mathematical design thinking. https://www.sciencedirect.com/science/article/abs/pii/S0732312318300245

Smith, K. M., & Boling, E. (2009). What do we make of design? Design as a concept in educational technology. *Educational Technology, 49*(4), 3–17.

Steinback, R. (2010). Building creative competence in globally distributed courses through design thinking. *Scientific Journal of Medial Literacy, 37*(19), 27-34.

Sumiyati, S. (2012). Review of related literature on performance assessment. https://digilib.uinsby.ac.id/10268/3/chapter%202.pdf

Thurston, M. & Hayes, L. (2021). Will the 5th industrial revolution be the next renaissance? https://www.aurecongroup.com/blog/posts/5th-industrial-revolution-next-renaissance

Tumamao, M. (2016). Science audio-mics modules. Mariano Marcos State University.

Verma, S. (2020). Design thinking skills: Top 5 best reasons why school students must learn. https://idreamcareer.com/blog/design-thinking/

Wei, R. C., Schultz, S., & Pecheone, R. (2012). Performance assessments for learning: The next generation of state assessments.https://scale.stanford.edu/sites/g/files/sbiybj14851/f/aera_2012_paper_performance_assessment_for_learning_final.pdf